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THE RAT TAPEWORM, *HYMENOLEPIS DIMINUTA*,
IN MAN

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Cases of the occurrence of the rat tapeworm, *Hymenolepis diminuta*, as a parasite of man are of such rarity as to merit special record. Moreover, many important facts regarding the life history of this worm have been brought to light since the comprehensive review by Ransom (1904), and a general discussion of the subject seems desirable.

UNREPORTED CASE

In August, 1921, an infant, nine months of age, was brought to the Miller Hospital Clinic, St. Paul, Minnesota. Her mother stated that the child was suffering from an intestinal upset, with green, foul smelling stools. She stated that the bowel movement contained worm segments. Examination of the stool showed these segments in numbers. In addition to the intestinal upset, the baby had an eczema, which was treated according to the usual way.

Apparently following this visit the baby got very much better and the mother did not return, in spite of the fact that she had been advised of the necessity of placing the baby in the hospital for treatment for the tapeworm. It was some three and a half months later that she decided she wanted the tapeworm taken care of. Her decision was forced by the fact that the child was extremely restless, especially at night, and that she was remaining stationary in weight, in spite of a fairly rational diet. The baby was placed in the hospital and treatment instituted. The treatment was only partially successful, for although about twenty worms were recovered, careful examination failed to reveal any complete specimens, and at the time of writing, a month later, segments are still present in the stool. The results of the treatment have been partially satisfactory in that the child has been much better since the hospital regime. The discharged worms agree in every respect with descriptions and specimens of *Hymenolepis diminuta*, except in scolex characters, which were not available. The child had been breast fed, and reared in a good home, in a cleanly environment. The clue to possible sources of infection was obtained when the mother stated that in mid-summer at the age of seven months it had been allowed to creep on a grassy plot in the yard.

SOURCES OF INFESTATION

Hymenolepis diminuta is the most common of the rat tapeworms. It is reported not only for various species of rats, but also for the common mouse. Few data relative to its frequency in these rodents are available and as is often the case in statements regarding infection, some of the figures are open to the suspicion of being vitiated by examination of animals from centers of infection.

We have found it in 14 per cent. of rats examined in Minneapolis and St. Paul. Moll (1917) reports it in five out of twenty-five examinations at Madison, Wisconsin. Grassi found it in 20 to 30 per cent. of Italian rats. Joyeux states that 18 out of 101 rats captured in Algeria were infested and 15 out of 25 in Salonica. Brumpt found it in 55 per cent. of the Norway rats examined in Paris, but states that it was rare in mice.

The researches of Grassi and Rovelli showed that the cysticeroid of this rat tapeworm developed in the body cavity of a surprising range of meal-infesting insects. This work has been fully reviewed by Ransom (1904) and is very generally cited in the literature. These authors found that development occurred in the larvae and adult of a moth, *Asopia farinalis*, in both nymphs and adults of the earwig, *Anisolabis annulipes*, and in adults of the tenebrionid beetles, *Akis spinosa* and *Scaurus striatus*. Grassi considers that the lepidopter is the normal intermediate host.

With so wide a range of hosts, including two tenebrionid beetles, it would seem probable that the common meal-worm, *Tenebrio molitor*, would serve as an intermediate host of *Hymenolepis diminuta*. With this in mind one of us, and an enthusiastic student, Miss Olga Holie, made numerous attempts to infect these beetle larvae. These efforts were uniformly unsuccessful. We have since noted that this was the experience of Joyeux (1920) with larvae of *Tenebrio molitor*, but on the other hand, he found that adult beetles of this species were the most readily and uniformly infected of any of the numerous forms with which he experimented. We made no effort to infect the adults.

Dr. Nickerson informs us that in attempting to trace the source of a case of infection of a child in Minnesota (Nickerson, 1911), he found that some months previous to the noting of the worms "there had been a pest of myriapods (Julidae) which over-ran the house and were into milk pans and all over." Assuming that the child might have acquired its parasites through the accidental ingestion of one or more of these myriapods, Dr. Nickerson collected living *Hymenolepis diminuta* from rats, and fed them chopped up and scattered on leaves, etc., to young myriapods of the species *Fontaria virginica* and *Julus* sp. In both of these the cysticeroids were formed.

Nicoll and Minchin (1911) found the larval stage of *Hymenolepis diminuta* in about 4 per cent. (8 out of 207) of rat fleas, *Ceratophyllus fasciatus*, examined during the thirteen months. Usually there was a single cysticercoid present, but in some cases there were as many as three.

Then, in order to test their conclusion that the cysticercoids were those of *Hymenolepis diminuta*, a litter of young rats was separated from the mother as early as possible, isolated, and fed on boiled bread and milk. During three months frequent examinations of feces showed them free from tapeworms. Two of the rats were then fed daily on rat fleas mashed up in their food. This was continued for nineteen days, feeding being omitted on three of these. At this time one of the rats died. No ova had been found in its feces but there were present in the alimentary canal five specimens of *H. diminuta* varying in size from 1 cm. up to 40 cm. On the next day numerous ova were found in the feces of the second rat. The check rats of the litter were observed for two months but no tapeworm eggs were found. The experiment was repeated later with similar result, ova appearing in the feces on the nineteenth day. The rat which had survived the first experiment was eventually killed and nine worms were found. The total of 14 tapeworms recovered was the result of feeding 340 fleas, which indicates that about 4 per cent. contained cysticercoids—a result agreeing with the number found in fleas which were actually dissected. From this it was evident that the complete development of *Hymenolepis diminuta* in the definitive host took place in less than three weeks. Calandruccio found ova in his feces fifteen days after he had experimentally swallowed the cysticercoids of this species, so it is evident that the worms mature in from two to three weeks.

The findings of cysticercoids in the bodies of *Ceratophyllus fasciatus* were confirmed by Johnston (1913) in Australia. He also found that the flea *Xenopsylla cheopis* might harbor the cysticercoids.

Joyeux (1920) found these two species of rat fleas so easily infected that he regards them, and the adult *Tenebrio molitor* as the natural intermediate hosts of *Hymenolepis diminuta*. Infection of fleas occurs only during the larval stage of the insects. This relation between the flea and the rat tapeworm is not surprising when it is recalled that the larval fleas develop in the debris and rat feces where rats abound. Joyeux was also able to infect experimentally larvae of the fleas, *Leptopsylla musculi*, *Pulex irritans* and *Ctenocephalus canis*.

CASES OF HYMENOLEPIS DIMINUTA IN MAN

As already noted, Ransom (1904) has already reported twelve cases of the occurrence of *Hymenolepis diminuta* as a parasite of man. In this number was included the experimental infection of Calandruccio.

To these should be added not only the one herein reported, but also the following 41 cases already noted in the literature, and 7 in the addendum to this article, making a total of 61 infections known for man. This total counts the report of Hoki (1917) as a single case.

Deaderick, 1906..... 1 case

A white boy, 8 years old, who had never been outside of Lee County, Arkansas, had a ravenous appetite, slight nausea, and pain in the epigastrium for two weeks. Examination of the feces showed about 10 ova of *Hymenolepis diminuta* in the preparation.

After a saline the night before the boy was given 25 drops of oleoresin of male fern. There were discharged four long fragments, measuring 12, 17, 21 and 25 c.c. (obviously a misprint for cm.) and then shorter fragments from 2 to 7.5 c.c. (cm.). One of the long fragments was expelled by the salts before the male fern was given. Unfortunately no head was found.

Five days later, the feces were examined and no ova found. The father reported entire relief from the mild symptoms present before treatment.

Garrison, 1907..... 1 case

Examinations of 4,106 prisoners in the Philippine Islands revealed one case of infestation by *Hymenolepis diminuta*. The host was a Chinese prisoner who was freed before there was opportunity to obtain data, so it is an open question as to whether the infection was imported or contracted in the Philippines.

Condorelli-Francaviglia, 1908..... 1 case

We have no data relative to this case other than the bibliographic record. The title indicates that the patient was a young girl who had a concurrent infestation of *Hymenolepis diminuta*, *Ascaris lumbricoides* and larvae of *Calliphora*.

Galli-Valerio, 1910..... 1 case

A woman in the interior of Brazil, June 10, 1909, in the practice of a Dr. Rondino. No further data.

Nickerson, 1911..... 1 case

A case of infection of a child in Minnesota is mentioned in connection with a brief report on the possibility of Myriapods serving as intermediate hosts for *Hymenolepis diminuta* (see below). In a recent letter to us, Dr. Nickerson states that the case was that of a child about two years of age, at Hanley Falls, Minnesota.

Noc, F., 1911..... 1 case

Martinique, French West Indies. No data.

Rijo, G., 1911..... 1 case

Listed by Joyeux (1920). No data.

Leiper, R. T., 1913..... 1 case

Records a case in a child at Grenada, West Indies.

Parodi, 1915 1 case

Argentine Republic. Listed without data by Joyeux (1920).

Hoki, R., 1917..... (?)

In a Japanese medical journal, Hoki reports on the examination of soldiers from the Loochoo Islands. An abstract in the Tropical Disease Bulletin states that the "author identified an egg which agreed in morphology and measurements with that from a rat (*M. decumanus*) and Braun's illustrations of *Hymenolepis diminuta*. A drawing of the head is somewhat different and is reproduced on account of possible taxonomic value."

Shircore, 1917..... 1 case

In the course of 1,500 examinations of feces of native East Africans at the hospital in Mombasa, of Indians of the Expeditionary Force, and of Washikira Arabs of the Arab Rifles, there was found one case, an Arab, infested by *Hymenolepis diminuta*.

Gonzaga and Carvahlo, 1918..... 16 cases

Sixteen cases out of 2,725 subjects, or 0.58 per cent., State of Sao Paulo, Brazil. Cited by Joyeux.

Acton, 1919..... 8 cases

Two thousand nine hundred and eighty-one routine examinations of Indian members of the Mesopotamian Expeditionary Force revealed 8 cases (0.2 per cent.) of *Hymenolepis diminuta*.

Gedoelst, 1920..... 1 case

That of a Belgian infected while serving in the Belgian Congo on military duty, between 1916 and 1919.

Schwartz, 1921..... 1 case

Before the Helminthological Society of Washington, Dr. Schwartz reported a case of this tapeworm in the child 2½ years of age, in the practice of Dr. C. C. DuBoise of Warsaw, Indiana. Gravid segments had been collected from the stool and it was stated that the child had passed several feet of tapeworm on a previous occasion.

Cort, 1921..... 1 case

In the discussion of the report by Schwartz, Dr. Cort mentions that "Dr. Mallory had found a case of the same sort in Nicaragua." Dr. Cort informs us that he is unable to furnish data as to the age of the patient.

Stiles, 1921..... 3 cases

On the same occasion Dr. Stiles mentioned three unpublished cases of *Hymenolepis diminuta* in man that had come to his attention. In one case, specimens were collected by Dr. Talcott, at Greenwood, Nebraska in 1906, in another by Dr. Constans, at Washington, D. C., in 1911, and in another by Dr. Leonard at Gastonia, N. C. In a recent letter to us Dr. Stiles states that the patients in each case were children aged, respectively, 2 years, 12 years, and 17 months.

AGE DISTRIBUTION

The age distribution of 14 out of the total 54 cases is definitely stated as follows: 9 months, 17 months, 19 months, 20 months, 2 years (4 cases), 2½ years, 3 years, 8 years, 11 years, 12 years (2 cases). Of the remaining 40, three were noted merely as children. A total of 15 were adults, ten of them having been brought to light through the examination of troops. Concerning twenty-two (including Gonzaga's and Carvahlo's 16), we have no available data.

In this connection it is of interest to note that, in as far as published, extensive examinations of troops in this country have not revealed any cases of *Hymenolepis diminuta* infestation. A striking illustration is afforded by Lucké (1919), who in the study of the prevalence of intestinal worms in 35,000 white and colored troops of Camp Zachary Taylor, Kentucky, found no such case, although he did find 238 cases of *Hymenolepis nana*. Kofoid, Kornhauser and Plate (1919) in the course of examinations of 1,200 overseas and 300 home service troops found *H. nana* 7 times (all overseas men) but no *H. diminuta*.

The case which we report holds the record of early infection by *Hymenolepis diminuta*, since infection occurred before the ninth month.

On the other hand, Vacca (1909) has noted infection by the double-pored tapeworm, *Dipylidium caninum*, which also develops in the flea, in an infant of about twenty days. At this time the child began to suffer from an enteritis which was resistant to treatment. Toward the second month, there were found in its dejections three white segments. About a month later, the enteritis continuing, and the infant being restless, and later in a stupor, with an enormous papillary dilation, a physician was consulted. On treatment, at the age of three and a half months, the infant discharged a worm 105 mm. long, without either head or neck. The health of the child was progressively established. The only animal living in the family of the patient was a cat brought into the house six days after the birth of the child, i. e., about twelve days before the beginning of the intestinal troubles. The cat was killed and found to contain 31 specimens of *Dipylidium caninum*. The fleas living in the fur of the cat were also examined; one of them harbored cysticercoids in its body cavity.

Of 76 authentic records of human infestation by *Dipylidium caninum* 23 cases, or 30.26 per cent. of the total were in children under six months of age, while over 65 per cent. were under three years. This great percentage of prevalence of this tapeworm in infants is due to the fact that its development takes place primarily in the cat or dog flea and that babies are very often exposed to possible infection indirectly from pet dogs or cats.

ADDENDUM

Since this paper was presented before the Helminthological Society of Washington there have come to the attention of the senior author seven additional cases of infestation of humans by *Hymenolepis diminuta*. The total figure mentioned in the body of the text has been revised to include these, making a grand total of 61 cases known. The available data regarding the seven cases are as follows:

Chandler (1922) records three not previously reported cases of *Hymenolepis diminuta* observed in the course of hookworm resurvey work in Louisiana and in Georgia. These were:

1. Boy, aged 7, white, Mansfield, De Soto Parish, La., July 30, 1921.
2. Boy, aged 13, negro, Clontierville, Natchitoches Parish, La., June 19, 1921.
1. Boy, aged 7, white, Mansfield, De Soto Parish, La., July 30, 1921.

Dr. Chandler also informs us in correspondence that he had omitted from his summary a case reported by De Bugs and Dwyer, 1919.

Dr. C. W. Stiles has kindly furnished us data regarding a fourth unreported case in the collections of the U. S. Public Health Service. This specimen was collected by Dr. Hopkins at Richmond, Va. The patient was a child 2 years old. It should be noted that through a misunderstanding this child's case was confused with that submitted to the Public Health Service by Dr. Talcott. The data with the latter specimen made no mention of the age of the patient.

Through the courtesy of Dr. D. M. Molloy, director for Nicaragua of the work of the International Health Board, I have more detailed information concerning the case already noted and data concerning two additional cases, not included in the foregoing summary. The data are as follows:

Case No. 1 (1918).—Female child, 3½ years old, resident of Masatepe, department of Carazo. Under treatment for hookworm infection expelled two parasites which were classified by technician who strained the stools as *Hymenolepis nana* (which is quite common in Nicaragua). No data as to length of time infestation continued or the source of infestation. Parasites were later identified by me as *Hymenolepis diminuta*. Two parasites were expelled, one of which measured about 30 cm. in length (preserved in 5% formalin), and the other measured about 40 cm. These specimens were lost.

Case No. 2 (1919).—Female child, 9 years old. Four parasites were expelled after the taking of a purgative prescribed by a physician, who sent the specimens to the laboratory for identification. These specimens were sent later to the Naval Medical School in Washington, where the identification was verified and where the specimens now are. No data as to probable source of infection or length of time it had persisted. Child was lost sight of. Resident of the "sierras" of the department of Managua.

Case No. 3 (1920).—Female child 7½ years old, resident of the city of Managua. Diagnosis made on examination of feces for ova of intestinal parasites, the characteristic eggs of *Hymenolepis diminuta* being found, together with eggs of hookworm, *Ascaris* and *Tricocephalus*. The patient never returned to

the dispensary for treatment, hence no data of the source of infection or its probable duration collected. We are making an effort to locate this patient for collecting data and specimens.

Thus there are known at least 61 cases of infestation of man by *Hymenolepis diminuta*. These are distributed geographically as follows: Brazil, 19; United States, 16; India, 8; Italy, 7; Nicaragua, 3, and one each for Argentine, Belgium, Cuba, East Africa, Grenada, Japan, Martinique, and the Philippines.

It is quite probable that in extensive routine examinations the eggs of *Hymenolepis diminuta* have been at times mistaken for those of *Hymenolepis nana* and that the above figures should be considerably higher. On this point Dr. Molloy writes "This would naturally be the case with untrained technicians, who make their diagnoses with the aid of charts, and who have relatively little knowledge of the cestode parasites."

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